FERMILAB-LU-230

FERMILAB
ACCELERATOR DIVISION
MECHANICAL SUPPORT DEPARTMENT

Linac Upgrade RF LCW Cooling System

SPECIFICATION #

1302 -ES- 296071

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1. INTRODUCTION

This specification describes the mechanical requirements for the operation and maintenance of the RF Low Conductivity Water (LCW) cooling system. This system provides cooling for the linac upgrade klystrons, charging supplies and pulse forming networks (PFN) stations 1 through 7 including the transition section. Procedures for startup, continued operation, replacement of a klystron in the system, and solutions to possible failures of critical components in the cooling system are included.

2. OVERVIEW

The purpose of the RF LCW cooling system is to provide 95 F LCW cooling to the klystrons, charging supplies, and the PFN's. It consists of a piping network through the linac gallery stemming from three identical water skids. Pipe branches drop down from headers near the ceiling to the power supplies, PFN's, and each klystron (including a branch for a pair of T.V. klystrons). The pipe has been installed such that each individual component requiring water can be valved into the system independently.

The water supply skids each contain a 50 Hp motor close coupled to a centrifugal pump providing approximately 300 GPM with a head of 350 feet of water. Two water skids are operating in parallel when the klystrons and power components are on-line. The third skid will be used as a backup when repairs are necessary for one of the normally operating skids. The LCW system is a closed loop with the cooling provided by a plate heat exchanger and 50 GPM of house chilled water removing the heat. A three-way valve governs the amount of water passing through the heat exchanger by means of an automatic controller monitoring the temperature of the supply LCW. Approximately 8 GPM of the LCW cooling water is diverted through filters and deionization bottles in a polishing line to keep the LCW cooling water "clean" and an expansion tank provides a constant positive pressure on the suction of the pump for each water skid. Flow meters, thermocouples, pressure transducers, and resistivity probes monitor information necessary to provide the correct LCW cooling in the most efficient way.

All klystrons, power supplies, and PFN's will not be connected to the LCW cooling system at all times during future operation and repair times for the linac. Therefore, back pressure regulating valves have been installed at three locations in the piping system. These valves will open when the pressure increases in the system due to the lack of a load, such as a klystron which has been valved out for repair. The back pressure regulating valves are necessary to maintain a steady pressure in the supply lines and minimize variations in the flow through on-line components.

During failure of any component in the RF LCW cooling system, procedures will be followed to minimize down time of the klystron and power systems. Routine maintenance of the supply skids will be expedited with the use of available parallel backup systems.

3. DRAWINGS

The following drawings pertain to the RF LCW cooling system:

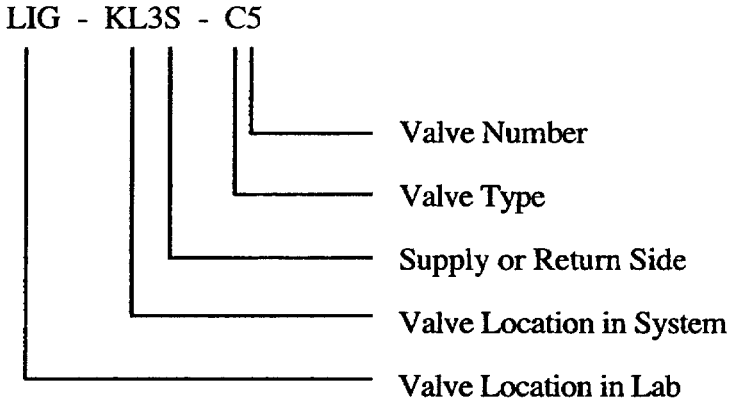
Drawing #	Title
0260-ME-300290	Linac Upgrade Klystron Cooling System Linac Hall Manifold Sections
0260-ME-300444	Linac Upgrade Klystron LCW Cooling Skid Supply Line Details
0260-ME-300447	Linac Upgrade Klystron LCW Cooling Skid Return Line Details
0260-ME-300448	Linac Upgrade Klystron LCW Cooling Skid Makeup and Bypass Details
0260-ME-300486	Linac Upgrade Klystron LCW Cooling Skid Cooling Water Line Details
0260-ME-300506	Linac Upgrade Klystron LCW Cooling Tank Assembly

4. PROCEDURES

During various phases of commissioning and operation of the linac upgrade project, procedures will be required to maintain the LCW system to accomplish proper cooling of the linac upgrade RF components. In the following subsections, these procedures have been arranged in a checklist format for clarity.

Identification of valves in the system is necessary to perform maintenance procedures and each valve has been marked as follows:

Example valve label:



With Valve Types as follows:

B - Butterfly
P - Pressure Regulating
R - Relief
C - Check
G - Globe
T - Three Way
NO DESIGNATION - Ball

With Valve Location in System as follows:

KL1 thru KL8 - Klystron Stations 1 thru 8
KLT - Klystron T.V. Station
PS1 thru PS7 - Power Supplies 1 thru 7
PF1 thru PF7 - PFN Stations 1 thru 7
PM1 & PM2 - Main Headers for PS & PFN's
BP1 thru BP3 - Back Pressure Regulators 1 thru 3
WS1 thru WS3 - Water Skids 1 thru 3

With Valve Location in Lab as follows:

LIG - Linac Gallery

In the following procedures, the Lab location (LIG) designation has been purposely omitted since all valves covered by this specification are located in the Linac Gallery. Refer to Figure 1A and 1B for a skid schematic and valve locations in the skid configuration respectively. Figure 2 shows valve locations in the piping system.

FIGURE 1A SKID SCHEMATIC

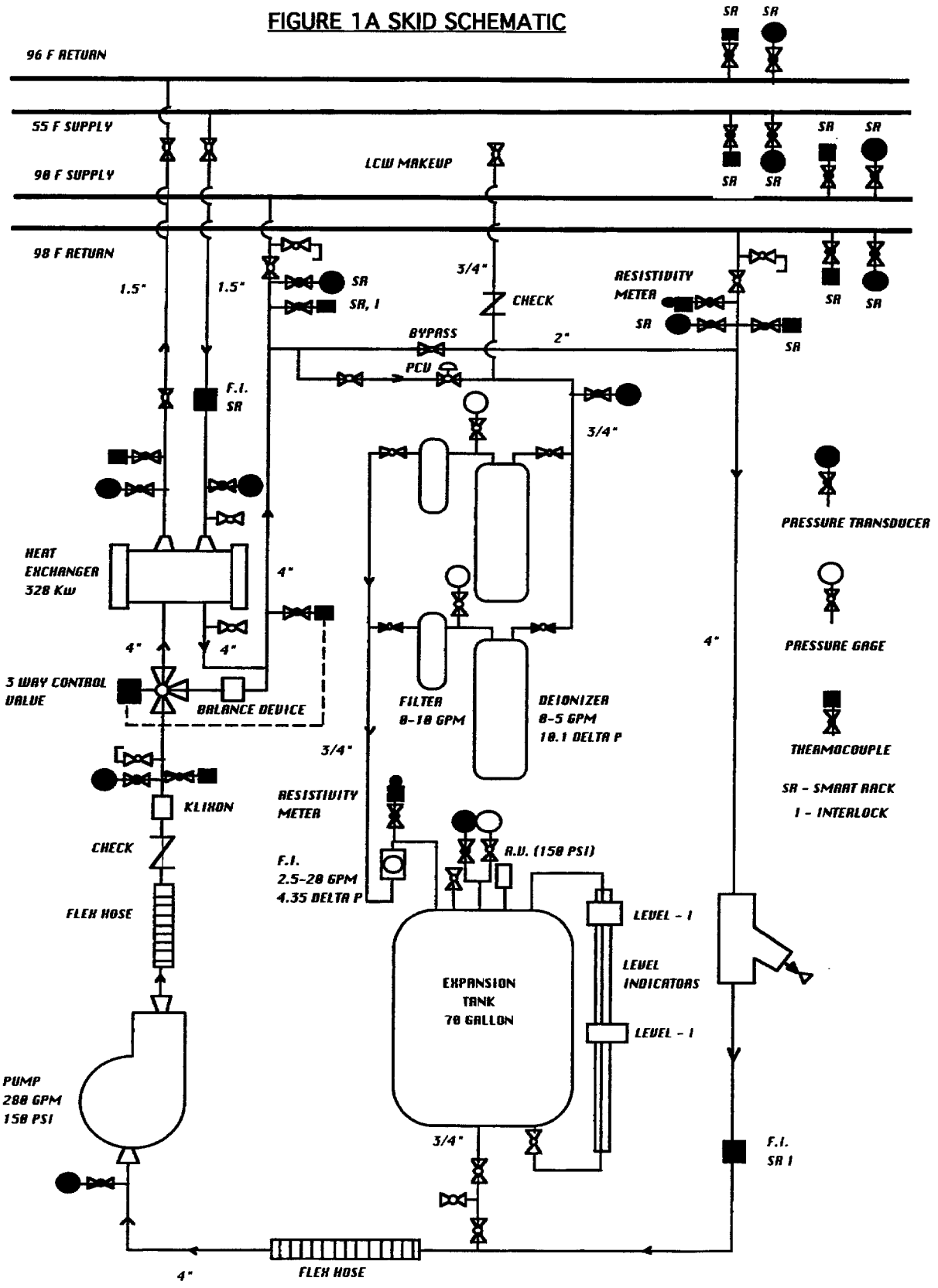


FIGURE 1B WATER SKID VALVE LABELS

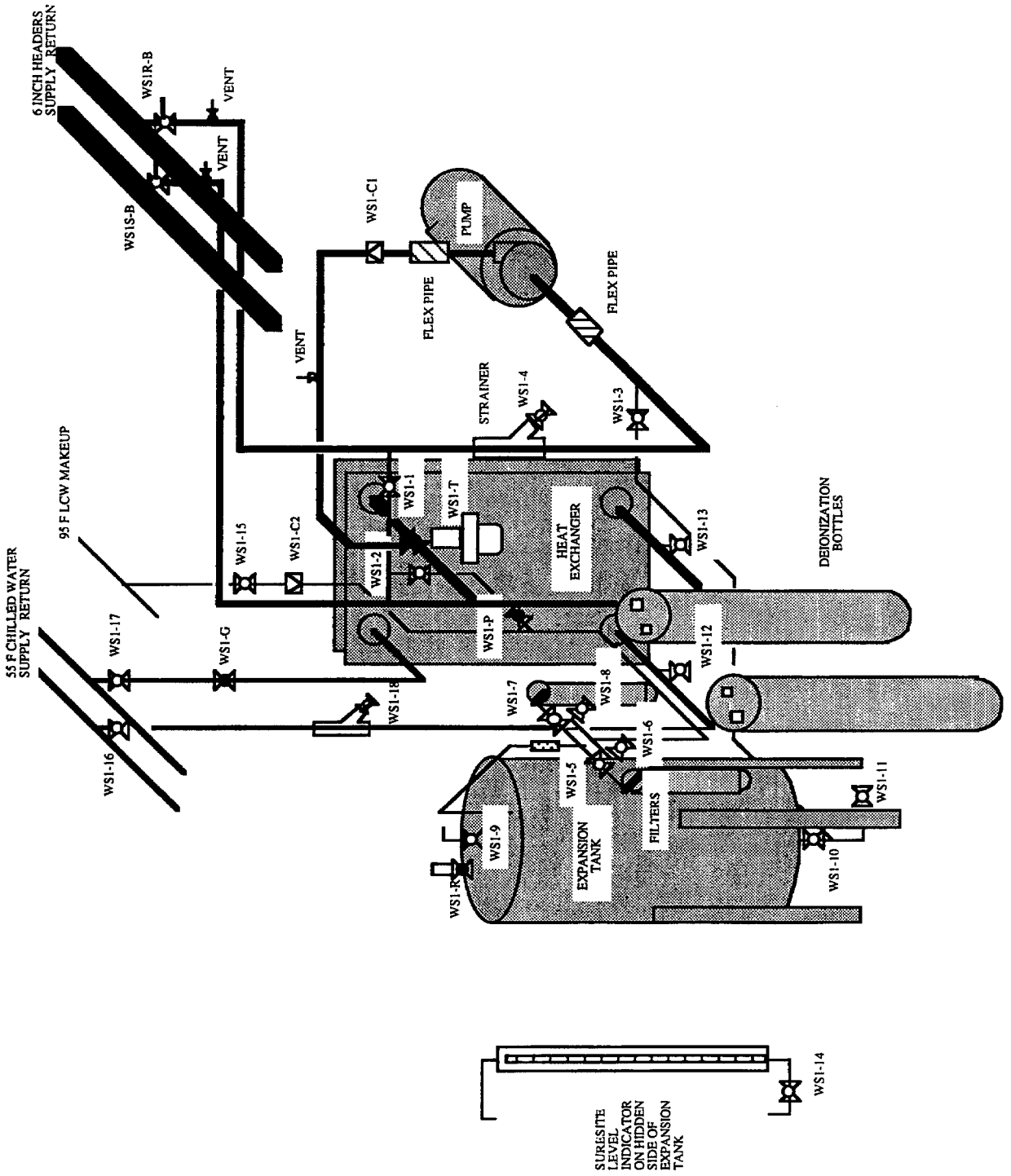


FIGURE 2A PIPING SYSTEM VALVE LABELING

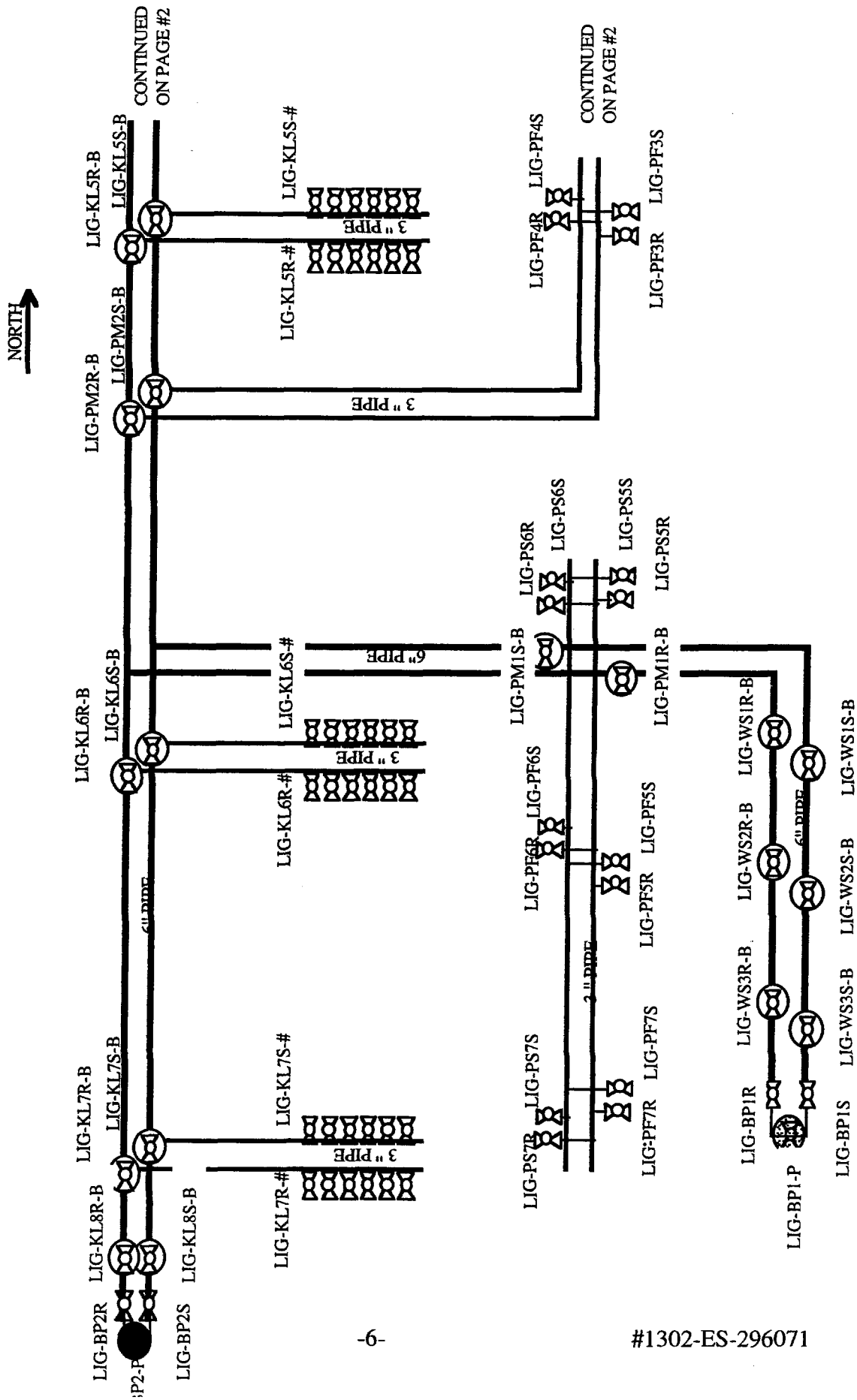


FIGURE 2B PIPING SYSTEM VALVE LABELING

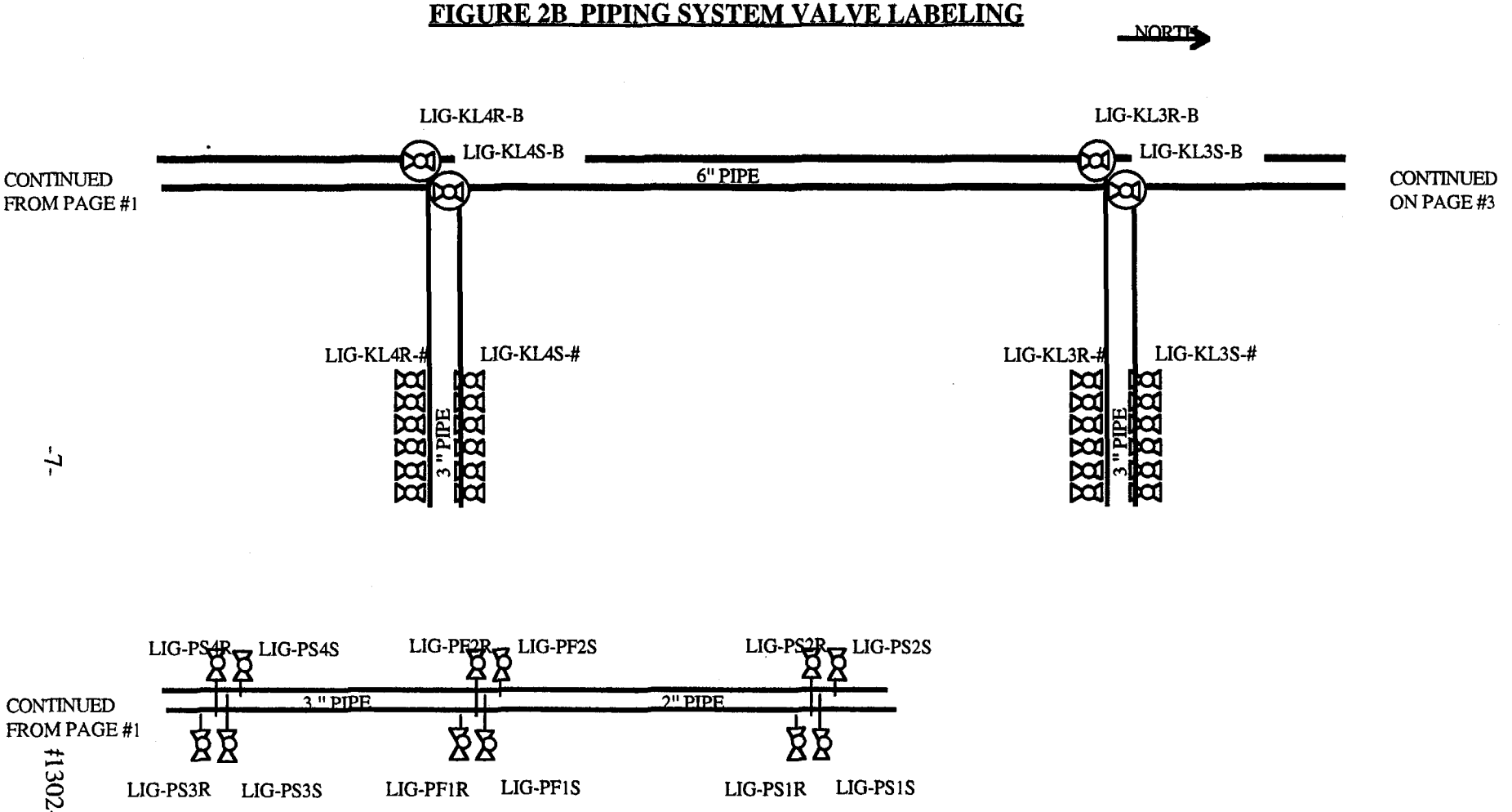
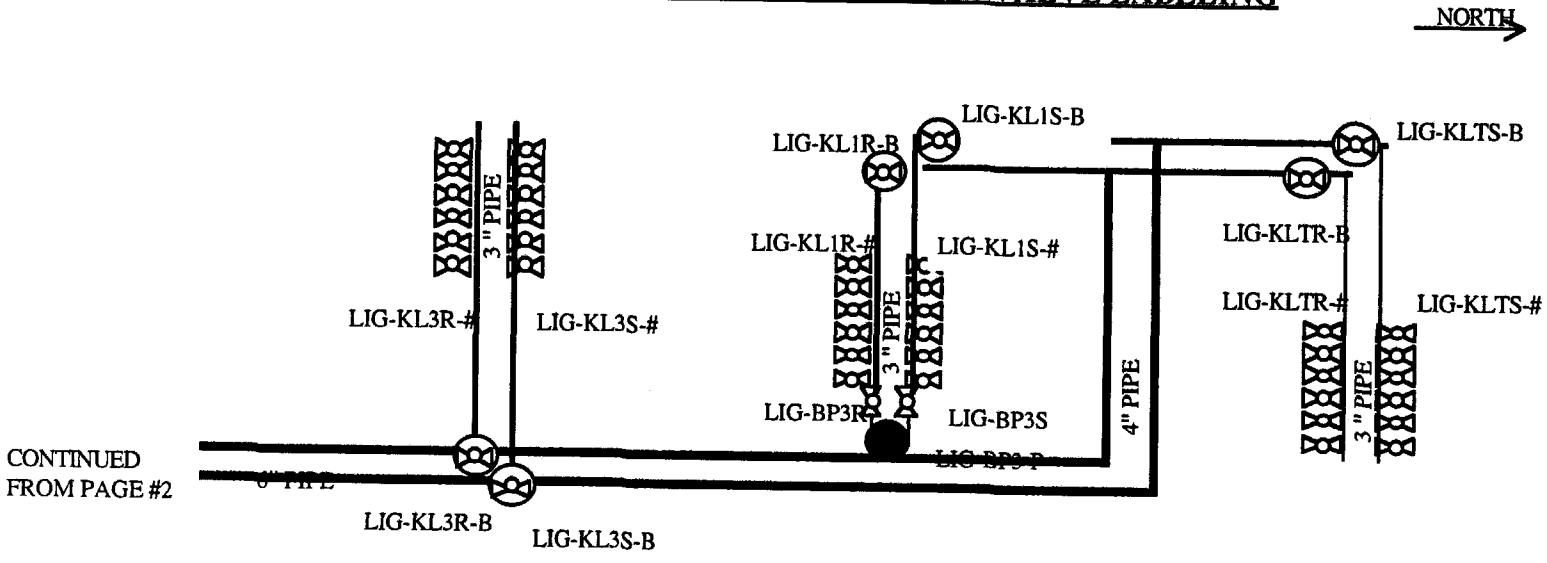


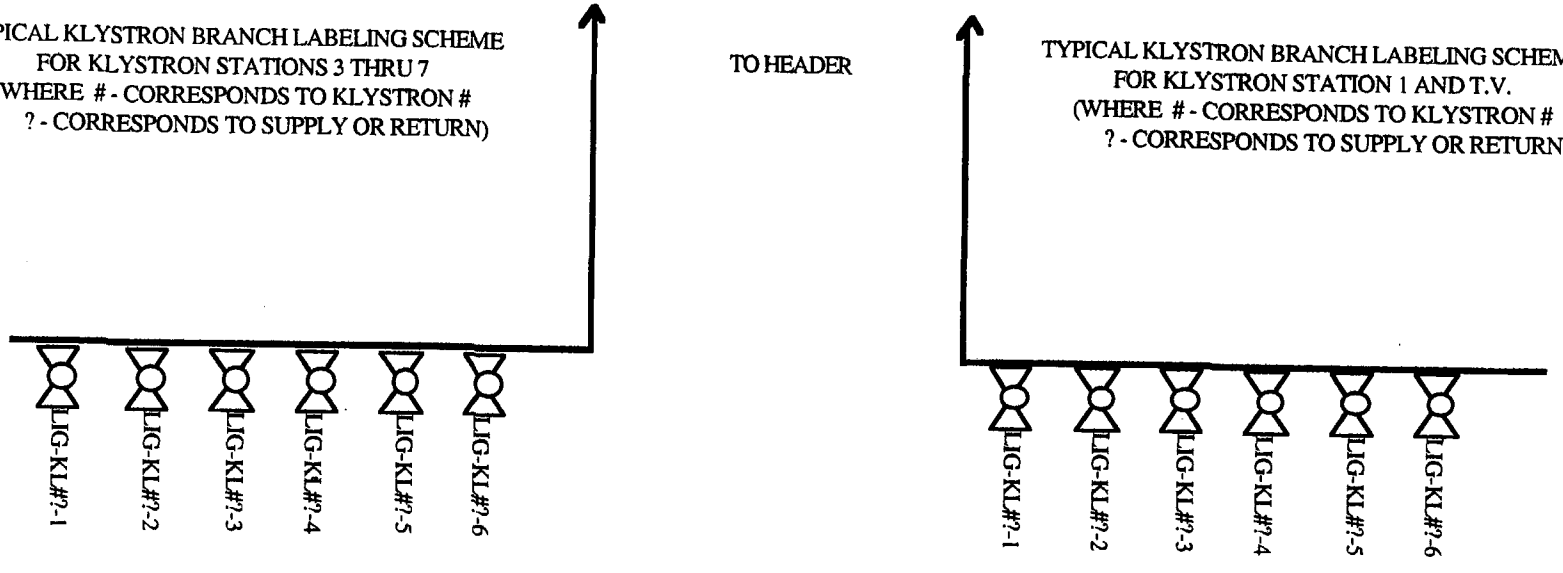
FIGURE 2C PIPING SYSTEM VALVE LABELING



TYPICAL KLYSTRON BRANCH LABELING SCHEME
FOR KLYSTRON STATIONS 3 THRU 7
(WHERE # - CORRESPONDS TO KLYSTRON #
? - CORRESPONDS TO SUPPLY OR RETURN)

TO HEADER

TYPICAL KLYSTRON BRANCH LABELING SCHEME
FOR KLYSTRON STATION 1 AND T.V.
(WHERE # - CORRESPONDS TO KLYSTRON #
? - CORRESPONDS TO SUPPLY OR RETURN)



4.1. LOCK-OUT/ TAG-OUT (LOTO)

Prior to most work performed on any of the three water skids in this system, the respective pump must be turned off, locked out, and tagged. The person responsible for the job must attach a proper lock and tag as designated by the Fermilab E.S.& H. department and is not to remove them until the job is complete and the system is safe to operate. Only the person attaching the lock and tag can remove them.

Each pump is connected to a 50 Hp motor starter in a NEMA 1 enclosure mounted on the wall adjacent to the water skids. The 100 amp circuit breaker on the side of each enclosure is for incoming 480 VAC short circuit protection and must be pulled down, locked out, and tagged for the corresponding pump or skid to be worked on. The NEMA enclosures are in the correct sequence on the wall matching the water skid order in the enclosure.

Safe maintenance can be performed on a water skid in some instances without turning off the pump. However, where lock-out/ tag-out for the pump is required, the enclosed procedures have it listed as a check item due to the dangers involved to both personnel and equipment.

4.2. STARTUP

4.2.1. SKID FILLING

In the following procedure, it is assumed that Water Skid #1 will be the added skid. If this is not true, simply replace WS1 designations with the correct skid number.

CHECKLIST

_____ Check that all drain valves (WS1-11,12,13) and strainer valve (WS1-4) in skid are closed. All other valves in skid should be open.

_____ Open three vents for the new skid. Two are located next to WS1S-B and WS1R-B and the third is located above the check valve WS1-C1 in the high portion of the water skid.

_____ INFORM CONTROL ROOM OF USAGE OF LCW WATER FROM 95 SYSTEM.

_____ Open LCW makeup line (WS1-15) into skid.

_____ As water exits vent lines, close individual vents and when all vents have been closed, close makeup line (WS1-15).

4.2.2. FILLING SYSTEM

In the following procedure, it is assumed that Water Skid #1 will be used as the filling station. If this is not true, simply replace WS1 designations with the correct skid number.

CHECKLIST

_____ All valves are initially closed except WS1-1,2,3,5,6, 9, 10, WS1S-B, and WS1R-B.

_____ INFORM CONTROL ROOM OF USAGE OF LCW WATER FROM 95 SYSTEM.

_____ Open LCW makeup line (WS1-15) into skid.

_____ Open vents in 6 inch header, 4 inch header, and at branch line running to power supplies and PFNs next to water skids.

_____ When water exits vent lines for branch line, close these vents, and open vents to branch line for Station 7.

_____ Continue process, moving north along Linac Gallery until all branches are filled. **CAUTION: Water will exit vents from 6 inch headers when filling Stations further north and the these vents must be closed when this occurs.**

_____ When final Transition Station branch has been filled, leave LCW makeup lines open until water exits high point vents in 4 inch headers. Close remaining vents at this time.

_____ Open quick disconnect at WS1-9 on tank in order to fill tank to designated level. Close quick disconnect and WS1-9 when tank has reached designated level.

_____ Close makeup line valve (WS1-15).

4.3. CONTINUED OPERATION

4.3.1. DISCONNECTING KLYSTRON STATION

In the following procedure, it is assumed that Klystron Station #1 and its corresponding Charging Supply and PFN are to be disconnected from the RF LCW cooling system. Replace KL1, PS1, and PF1 with the correct designations for other stations.

CHECKLIST

_____ Close supply line valves KL1S-1, 2, 3, 4, 5, 6, and PS1S.

_____ Close return line valves KL1R-1, 2, 3, 4, 5, 6, and PS1R.

_____ Disconnect hoses at quick disconnects.

4.3.2. CONNECTING KLYSTRON STATION

In the following procedure, it is assumed that Klystron Station #1 and its corresponding Charging Supply and PFN are to be connected to the RF LCW cooling system. Replace KL1, PS1, and PF1 with the correct designations for other stations.

CHECKLIST

_____ KL1S-1, 2, 3, 4, 5, 6, KL1R-1, 2, 3, 4, 5, 6, PS1S, PS1R, PF1S, and PF1R must be closed.

NOTE: In the following, if difficulties are encoutered while connecting quick disconnects, remove plug from the strainer valve and open valve into a bucket to relieve the pressure in the hoses. Replace plug.

_____ Connect Klystron collector supply and return hoses to KL1S-6 and KL1R-6 respectively. Strainer is located on supply line. Flow meter is located on return line. (1 " hose is used with quick disconnect)

_____ Connect Klystron solenoid A supply and return hoses to KL1S-5 and KL1R-5 respectively. Strainer is located on supply line. Flow meter is located on return line. (3/8" hose is used with quick disconnect)

_____ Connect Klystron solenoid B supply and return hoses to KL1S-4 and KL1R-4 respectively. Strainer is located on supply line. Flow meter is located on return line. (3/8" hose is used with quick disconnect)

_____ Connect Klystron body supply and return hoses to KL1S-3 and KL1R-3 respectively. Strainer is located on supply line. Flow meter is located on return line. (3/4" hose is used with quick disconnect)

_____ Connect Klystron transformer supply and return hoses to KL1S-1 and KL1R-1 respectively. Strainer is located on supply line. Flow meter is located on return line. (3/8" hose is used with quick disconnect)

_____ Connect Charging Supply supply and return hoses to PS1S and PS1R respectively. Strainer is located on supply line. Flow meter is located on return line. (Hytron Non-conductive 1/2" hose is used)

_____ Connect PFN supply and return hoses to PF1S and PF1R respectively. Strainer is located on supply line. Flow meter is located on return line. (Hytron Non-conductive 1/2" hose is used)

For each of the above connections, perform the following steps:

_____ Secure bucket or other means of catching water that will be released through strainer and open valve on strainer.

_____ Open return line valve and let water flush through line and out strainer valve for 30 seconds.

_____ Close and plug valve attached to strainer and open supply line valve slowly.

_____ Check expansion tank levels in water skids and keep filled to designated level.

_____ Check for leaks.

_____ KL1S-2 and KL1R-2 are joined by a 1/4" hose for a bypass line. KL1S-2 and KL1R-2 remain closed when water is flowing thru klystron. They are opened only when all other valves are closed on the respective branch so that water in the branch does not become stagnant.

4.4. MAINTENANCE

4.4.1. BACKUP SKID

In the event of failure of one of the water skids, a backup skid will be operated during the repair period. The following procedure will assure a proper switch to the backup system:

CHECKLIST

_____ Turn off power to all three water skids.

_____ Close WS#-16 chilled water supply valve of skid in need of repair.

_____ Close WS#-17 chilled water return valve of skid in need of repair.

_____ Close WS#-3 and WS#-2 of skid in need of repair.

_____ Disable interlock for skid in repair by use of the toggle switch.

_____ Open WS#-17 chilled water return valve of backup skid.

_____ Open WS#-16 chilled water supply valve of backup skid.

_____ Open WS#-3 and WS#-2 of backup skid.

_____ Enable interlock for backup skid by use of the toggle switch.

_____ Turn power on to two skids for continued operation.

4.4.2. WATER SKIDS

In the following procedures, it is assumed that Water Skid #1 will be the skid work is to be performed on. If this is not true, simply replace WS1 designations with the correct skid number.

4.4.2.1. PUMP

CHECKLIST

_____ Turn off power and follow lockout/tagout procedure for skid work is to be performed on.

_____ Close WS1S-B, WS1R-B, WS1-1,10.

_____ Connect hose to WS1-11 for discharge of water.

_____ Open WS1-11, and vents above WS1-C1 and next to WS1R-B. Close WS1-11 after draining is complete.

_____ Remove threaded rod containing check valve.

_____ Remove check valve and portion of pipe with flex pipe between it and the pump by removing bolts at discharge of pump.

_____ Remove bolts connecting pipe to suction of pump.

_____ Remove 4 nuts securing pump to pump platform.

_____ Lift pump **VERTICALLY** off base, being careful not to bend threaded rod protruding from pump platform.

_____ When replacing pump, follow above instructions backward replacing check valve, all bolts, and threaded rod. Refill skid with 95 LCW thru makeup line as described in SKID FILLING.

_____ Remove lockout/tagout restrictions and turn power on to appropriate skid.

4.4.2.2. THREE WAY VALVE

CHECKLIST

_____ Turn off power and follow lockout/tagout procedure for skid work is to be performed on.

_____ Close WS1S-B, WS1R-B, WS1-1, 3. Open vents next to WS1S-B and above WS1-C1.

_____ Connect hose to drain (WS1-13) and run other end of hose to discharge area.

_____ Open WS1-13 and completely drain. Close WS1-13 after draining is complete.

_____ Remove digital meter panel from front of enclosure and secure in an upright position. A clear opening shall then exist thru the meter box door to the valve itself.

_____ Once the three way valve is properly rigged and supported, the bolts connecting it to the piping system can be removed.

_____ The valve can then be removed thru the meter box and enclosure being careful not to damage the valve, electrical boxes, or nearby objects.

_____ After repair of the three way valve, installment of the valve shall follow steps in reverse order of the above. Filling the skid shall follow the procedure found in SKID FILLING.

_____ Remove lockout/tagout restrictions and turn power on to appropriate skid.

4.4.2.3. 4" HOFFER FLOW METER

CHECKLIST

_____ Turn off power and follow lockout/tagout procedure for skid work is to be performed on.

_____ Close WS1S-B, WS1R-B, WS1-1,10 and open the vents next to WS1R-B and WS1-C1.

_____ Connect hose to drain (WS1-11) and run other end of hose to discharge area.

_____ Open WS1-11 and completely drain. Close WS1-11 after draining is complete.

_____ Remove flow meter for maintenance and replace.

_____ Clean strainer by opening valve WS1-4 and removing screen. Clean screen and replace. Close WS1-4.

_____ Refill skid with 95 LCW thru makeup line as described in SKID FILLING.

_____ Open butterfly valves WS1S-B and WS1R-B.

_____ Remove lockout/tagout restrictions and turn power on to appropriate skid.

4.4.2.4. 1 1/2" HYDRIL FLOW METER

CHECKLIST

_____ Turn off power and follow lockout/tagout procedure for skid work is to be performed on.

_____ Close WS1-16 and WS1-17.

_____ Connect hose to drain (WS1-12) and run other end of hose to discharge area.

_____ Open WS1-12 and drain completely. Open WS1-18 for venting purposes. Close WS1-12, 18 after draining is complete.

_____ Remove flow meter for maintenance and replace.

_____ Open WS1-16 and WS1-17.

_____ Remove lockout/tagout restrictions and turn power on to skid work is completed on.

4.4.2.5. 4" STRAINER

The strainer has a 20 mesh stainless steel screen installed and should be cleaned periodically or if the pump suction pressure falls below 5 psi and expansion tank pressure remains stable.

CHECKLIST

_____ Clean the strainer by removing the plug in WS1-4 and opening it such that it flushes into a bucket.

_____ Close WS1-4 and re-plug.

_____ Add makeup water thru WS1-15 as needed.

Replacement of the 20 mesh screen requires the drainage of the 4 inch pipe containing the strainer. This can be accomplished by closing WS1R-B and WS1-1 and flushing as described above until drained. The screen can then be replaced.

4.4.2.6. DEIONIZATION BOTTLES AND FILTERS

The resistivity of the water in the system must be kept as high as possible for efficient use of the power components. When there is a drop in the resistivity, the deionization bottles and filters should be changed. A constant resistivity of at least 5 megaohm-cm must be maintained.

CHECKLIST

_____ Close valves WS1-5,6,7, and 8.

_____ Drain filters and hose connecting filters to deionization bottles thru plug valves at bases of filters.

_____ Disconnect deionization bottles' hoses and replace bottles with regenerated ones.

_____ Reconnect hoses.

_____ Replace filters by unscrewing filter bodies from hose connection caps. Filters are 20 micron type.

_____ Reconnect filter bodies.

_____ Open valves WS1-5,6,7, and 8.

_____ Add makeup water thru valve WS1-15 as needed.

4.4.2.7. EXPANSION TANK AND LEVEL INDICATORS

The purpose of the expansion tanks are to provide water for makeup due to a small leak and to provide a constant positive pressure on the suction of the pumps. Approximately 70

gallons are contained in each tank and approximately 8 gallons of water are circulated thru each after exiting the filters and deionization bottles to act as a polishing system.

A Suresite level indicator is provided on the side of each tank and three switches are mounted to the pipe containing the indicator. The uppermost switch indicates if the tank level has risen above the safe level and the lowermost switch will be affected if the water level falls below a safe level. If the level rises too high, this is an indication of improper pressure distribution in the system or that the water temperature is at an unsafe level such that the water has expanded significantly. If the level falls too low, this is an indication of improper pressure distribution once again or else there is a leak somewhere in the system. Both the highest and lowest switches will turn the corresponding skid pump off if activated. There is a middle switch for an early warning signal of a falling tank water level. This warning is shown as a flashing red light on the interlock box and will not turn the pump off. Therefore, a small leak or minor malfunction of the system can be located before the system shuts down.

When changes in klystrons or other parts of the system are performed, the water levels in the operational tanks may be affected significantly. For instance, the addition of a new or replacement klystron will be filled with clean water from the system thus dropping the expansion tank levels. This can be remedied by opening the LCW makeup line and filling the tanks to the designated level.

4.4.2. KLYSTRON STATIONS

4.4.2.1. TURBINE FLOW METERS

Each turbine flow meter in the klystron branches, charging supplies, and PFN's consists of two main components that may fail. The turbine may become immovable due to pariculates in the water or the magnetic pickup may fail.

Replacement of the magnetic pickup simply requires disconnecting the cable and unscrewing the pickup from the flow meter. Install new magnetic pickup. **IMPORTANT: INSTALL MAGNETIC PICKUP ONLY FINGER TIGHT.**

Replacement of the turbine flow meter requires the drainage of the attached hose. This can be accomplished by the following:

_____ Close supply line valve.

_____ Close return line valve.

_____ Remove plug from the strainer valve and crack open into a bucket to relieve the pressure in the hoses.

_____ The turbine flow meter can then be removed and replaced.

_____ Close strainer valve and re-plug.

_____ Open return line valve.

_____ Open supply line valve.

_____ Add makeup water thru water skid makeup line as needed.

4.4.2.2. STRAINERS

Each strainer in the klystron branches, charging supplies, and PFN's has a 60 mesh stainless steel screen installed and should be cleaned periodically or when flow becomes restricted.

CHECKLIST

_____ Clean the strainers by removing the plug in the valve and opening it such that it flushes into a bucket.

_____ Close valve and re-plug.

_____ Add makeup water thru water skid makeup line as needed.

Replacement of the 60 mesh screen requires the drainage of the attached hose. This can be accomplished by the following:

_____ Close supply line valve.

_____ Close return line valve.

_____ Remove plug from the strainer valve and crack open into a bucket to relieve the pressure in the hoses.

_____ The screen can then be replaced.

_____ Close strainer valve and re-plug.

_____ Open return line valve.

_____ Open supply line valve.

_____ Add makeup water thru water skid makeup line as needed.

5. TROUBLE SHOOTING

Digital meters occupy the front center panel of each water skid and are necessary for monitoring the operation of the systems. Critical characteristics of each skid have alarms set to notify the Main Control Room when tolerances are exceeded. Other meters provide additional monitoring and aide in tuning the system and trouble-shooting problems that may occur.

Figure 3 depicts the front center panel for each water skid and the location of the digital meters. These meters are listed in Table 1 with a nominal reading during normal operation of the system. The table also lists meters which send alarms and their tolerances. In order to speed corrective action when a alarm occurs, possible causes are given in the final column.

FIGURE 3

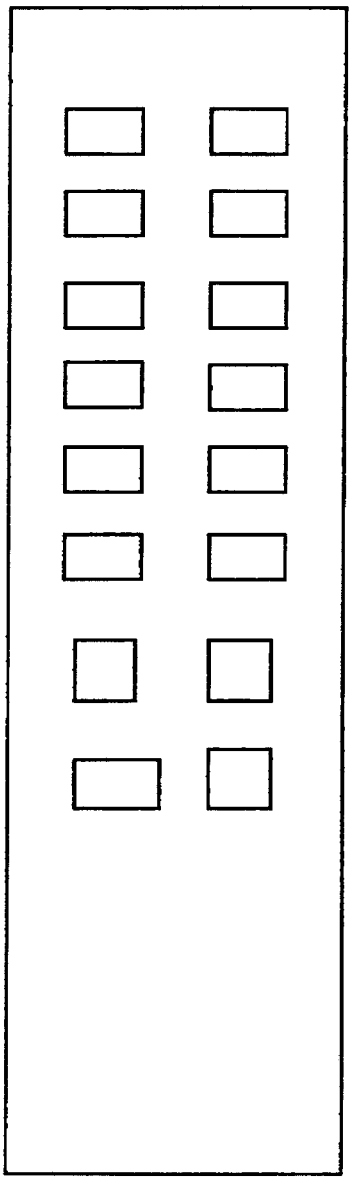


TABLE 1

DIGITAL READOUT	*NOMINAL READING*	*TOLERANCE (+ OR -)*	*ALARM*	*POSSIBLE CAUSES FOR ALARM*
PRESSURE SKID IN	10	NA	NO	
PRESSURE SKID OUT	150	20	YES	PUMP MALFUNCTION, LEAK IN SYSTEM, EXPANSION TANK PRESSURE TOO HIGH OR LOW, PUMP SUCTION PRESSURE TOO HIGH OR LOW
PRESSURE PUMP DISCHARGE	150	NA	NO	
PRESSURE PUMP SUCTION	7	NA	NO	
PRESSURE CHILLED WATER IN	100	NA	NO	
PRESSURE CHILLED WATER OUT	95	NA	NO	
CONTROLLER 95 F LCW	95 SET POINT	NA	NO	
95 F LCW FLOWRATE	300	50	YES	PUMP MALFUNCTION, BACK PRESSURE REGULATING VALVE MALFUNCTION, LEAK IN SYSTEM, PORTION OF SYSTEM VALVED OFF, STRAINER NEEDS CLEANING, FLOW METER MALFUNCTION
TEMPERATURE SKID IN	100	NA	NO	
TEMPERATURE SKID OUT	95	5	YES	CONTROLLER MALFUNCTION, HEAT EXCHANGER NOT COOLING PROPERLY, CHILLED WATER PROBLEMS
TEMPERATURE CHILLED WATER OUT	67	NA	NO	
TEMPERATURE HEAT EXCHANGER IN	102	NA	NO	

TABLE 1 (cont'd)

DIGITAL READOUT	*NOMINAL READING*	*TOLERANCE (+ OR -)*	*ALARM*	*POSSIBLE CAUSES FOR ALARM*
PRESSURE DEI & FIL SYSTEM IN	70	NA	NO	
PRESSURE EXPANSION TANK	10	NA	NO	
RESISTIVITY 95 F LCW	10	5	YES	DEIONIZATION BOTTLES NEED REGENERATION
CHILLED WATER FLOW RATE	50	10	YES	STRAINERS NEED CLEANING IN CHILLED WATER SYSTEM, CHILLED WATER BOOSTER PUMP MALFUNCTION, FLOW METER MALFUNCTION, HEAT EXCHANGER NEEDS CLEANING

NOTE: NA DESIGNATION SPECIFIES NOT APPLICABLE